**Gradient Corporation**

# TELEFAX MEMORANDUM

**To:** YWL **Date:** March 3, 1993

**From:** LCD

**Subject:** Rocky Flats Asbestos Emissions

As you requested, here are my "back of the envelope" calculations on asbestos emissions from a hypothetical building construction scenario at Rocky Flats. I hope these numbers are comprehensible and what you were looking for. If you have any questions, please call me.

Other than the emission equations themselves, the effects calculated herein are all linear, so the final emissions number can be scaled directly be making assumptions more or less conservative. As calculated, conservative assumptions are piled one on top of the other, and I believe the final number may be overly conservative as written. I have attached a set of emissions equation from a document which gives an alternative calculation very similar to the ones I have made. As you can see, the result from following this calculation gives emissions from storage piles almost two orders of magnitude lower than from the standard emission equations.

The maximum exposure to the hypothetical worker at the construction site would take place over a period of less than a day. This exposure is calculated at a maximum of $6.85 \times 10^{11}$ fibers per cubic meter of air. Less conservative calculation of this maximum exposure (lower fugitive emissions and fewer fibers per nanogram) leads to estimate emissions of $6.1 \times 10^{9}$ fibers per cubic meter. Average exposure to the worker during the three days of excavation postulated for the site would be $3.03 \times 10^{11}$ fibers per cubic meter as a maximum value and $6.0 \times 10^{9}$ fibers per cubic meter as a lower conservative estimate. After excavation, when only fugitive emissions are present, emission will be $5.1 \times 10^{7}$ to $3.82 \times 10^{11}$ fibers per cubic meter.

## Emission Calculations

The scenario I am considering is that of a house construction site where excavation is made for a full basement. This excavation is assumed to be 30 feet by 50 feet by 8 feet deep (444 cubic yards of material). I have assumed that emissions will take place from the excavation of this material and then from the storage pile as well as from the open excavation (the storage pile is assumed to be only 4 feet high and therefore twice the surface area of the original excavation).

Physical characteristic of soil and site:

- 75% asbestos content in soil (assumed, very conservative number)
- 50% silt in soil (assumed, conservative value)
- Mean wind speed 4 meters/second at site (materials you sent to me)



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ADMIN RECORD

A-OU07-000495

- Percent of time wind speed above 5.4 m/s 35% for site (calculated from wind rose)
- Soil moisture content 7% (based on semi-arid climate)
- Days of rain per year 90 (from map in EPA document, could be off as I am not certain of my Colorado geography).
- Fibers per gram $5 \times 10^{13}$ (middle of range of 11 to 108,000 fibers per nanogram reported in EPA, 1980). Another source cites a value of $10^{12}$ fiber per gram (IIT, 1977)
- Average excavation rate for a bulldozer 360 cubic yards per day.

Emissions of inhalable particles from excavation of material can be calculated using the following equation: Emissions = 0.45 * s^1.5 * M^-1.4. Emissions are in kg/hr, s is silt content in percent, and M is moisture content in percent. This equation assumes a bulldozer is being used (there is no factor for a backhoe, which would be a more appropriate piece of machinery). Using the average excavation rate of 360 cubic yards per day, and assuming that the excavation will take place over three days, we get an activity factor of 0.41 for excavation emissions (actual rate over average rate). From these inputs, an overall emission rate of 4.28 kg/hr, or 1.19 grams per second is calculated. This value is relatively high due to the high silt and low moisture content of the soil. These emissions will take place for three days while excavation is occurring. Emission also take place from dumping this material in a storage pile, but since those emission are generally about two orders of magnitude I have not calculated them other than to check that they are that much lower.

The other major source of emission is the exposed storage areas and surface areas of the excavation. The emission factor we use for these emissions is: Emissions = 1.9 * (s/1.5) * (365-p)/235 * (f/15). In this equation emissions are in kg/hectare/day, s is silt percent, p is number of days of rain per year, and f is the percent of time wind speed is over 5.4 m/s. From this equation emissions of 173 kg/hectare/day. With an exposed area of 1500 square feet for the excavation and 3000 square feet for the storage pile, there is 0.042 hectares of material exposed. This calculates out to 2 grams per second. Not all of this material will be in the respirable fraction, to be conservative assume that 75% is respirable, for respirable emissions of 1.5 gram/second.

In each case the total emissions need to be dispersed into some volume of atmosphere before they are available to the worker who is the exposed individual on the site. This can be done using a simple box model. As the most conservative case, take the fraction of a day when the excavation is almost completed, but is still being conducted, therefore both emission sources are fully active. In this case, total emissions are 2.69 grams/second. If 75% of this is asbestos, asbestos emissions are 2 g/s.

The box which I have uses assumes that the excavation and storage pile make up half of the work site area.; therefore the site covers 840 square meters, with dimensions of 60 by 100 feet (18.3 by 30.5 meters). The box will be assumed to extend upwards to the breathing zone (2 meters). With an average wind speed of 4 m/s, using the shortest axis (18.3 meters), 146 cubic meters of air flows through the site per second.

When emissions of 2 grams per second are apportioned into 146 cubic meters of air per second, the total concentration of asbestos dust will be 0.0137 gm/m$^3$. With the higher fiber density, this is $6.85 \times 10^{11}$ fibers per cubic meter of air. With the lower fiber density, it is $1.37 \times 10^{10}$ fibers per cubic meter.

If we look at the IIT report on asbestos emissions from storage piles alone (IIT, 1977), which uses an asbestos waste pile 810 square meters in size (twice the size of our pile), a emission rate of 0.09

kg/hour of 25% asbestos (0.027 kg/hr at 75% asbestos) is calculated for an active pile. Scaled down by 1/2 this leads to emissions of 0.075 g/sec from the storage pile. This is much lower than our calculated value. Carrying out the calculation, using their emission rates, we calculate $5.1 \times 10^8$ fibers/$m^3$ from the storage pile alone. This number could be treated as a lower bound for emissions during times when excavation is not taking place.

References

IIT Research Institute, 1977, Field Testing of Emission Controls for Asbestos Manufacturing Waste Piles. Chicago, IL. EPA-600/2-77-098.

USEPA, 1980. Health Impacts, Emissions, and Emission Factors for Noncriteria Pollutants Subject to 'De Minimis' Guidelines and Emitted from Stationary Conventional Combustion Processes. EPA-450/2-80-074.

USEPA, 1989. Air/Superfund National Technical Guidance Study Series, Volume 3: Estimation of Air Emissions from Cleanup Activities at Superfund Sites. EPA-450/1/89-003.

SECTION 5

ANALYSIS OF EMISSION CONTROL

EMISSION CONTROL COST EFFECTIVENESS ESTIMATES

In Section 4 of this report, the control techniques which might be applied to the task of reducing the emissions from asbestos cement waste dumping operations are discussed. In this section, the cost effectiveness of these techniques are estimated from the estimate of the cost of application of each technique and from the estimated reduction in the emissions brought about by that technique.

In order to estimate the cost and emission reduction factors, a hypothetical typical plant has been developed as a model. The plant is based on the Johns-Manville plant at Denison, Texas, as discussed in Section 3.

The estimation of fugitive emissions from a site is a difficult procedure and yet such estimates must be developed in order to provide a logical basis for the application of controls in the field testing program. The emission rates estimated in this study were found to be quite reasonable and realistic when compared to those obtained subsequently in the field study. They have been left unchanged in this section in order to present the methodology of control technology selection based on environmental engineering judgement and estimation techniques.

MODEL PLANT DETAILS

A model plant which manufactures asbestos-cement pipe is considered to be located in an urban area in the southwestern part of the United States. No effort is currently being used to mitigate the emissions from the waste dumping operations.

There are two types of asbestos-containing waste material originating in the plant which are taken to the dump:

- Reject asbestos pipe and scrap — 13.2 metric tons per day

- Fines from the baghouse — 0.9 metric tons per day

The daily production of asbestos cement pipe is about 200 metric tons. Production continues for six days per week for 50 weeks per year. The composition of the waste is approximately:

Cured Portland Cement — 45%

Quartz silica — 30%

Asbestos — 25%

Compare to our 75%

It is assumed to have a density of 1,760 $kg/m^3$ (100 $pounds/ft^3$).

The emissions from the dump area are assumed to have the same composition as the dumped waste (25% by weight of asbestos). It is further assumed that every nanogram of asbestos releases into the atmosphere 1,000 asbestos fibers as determined by electron microscopy.

other source indicates this is highly variable

Emissions from the dump area are considered to arise from four basic sources:

- Daily dumping of the waste onto the active dump area
- Crushing and leveling of the reject pipe by a bulldozer once a month
- Weathering of the active pile
- Weathering of the inactive pile

The active part of the dump is where waste material is currently being dumped. It is subject to disturbance by vehicular traffic and bulldozer activity, it has an assumed area of 810 $m^2$ (0.2 acres). At the end of one year, it is 3 meters deep and a new active dump area will be started. The southwestern area location means that the area will be dry (less than 1 m of rain annually) and, thus, the emissions will be in a high category.

ESTIMATION OF EMISSION FACTORS

Emissions from the Active Dump Site

Based upon the 14.1 metric tons/day of waste material generated, 2,400 $m^3$/year must be disposed. The active dump site at this plant is 810 $m^2$. At the end of one year, the pile will be 3 m deep, at which time a new dump area will be started.

This plant is located in that part of the southwest which receives less than 1 meter of rain annually. Thus, the surface of the waste pile is extremely dry most of the year and favors relatively high emission rates. In a study by PEDCo,[20,23] particulate emissions from tailings piles were developed for various climatic conditions. Because of the high moisture evaporation rate and the large number of fine particles contained in the asbestos pile, the highest listed emission rate was used for this waste material, 3,583 metric tons/$km^2$/yr, of which 25%, or 0.7 metric tons/yr, would be asbestos. Thus, the average emission rate from the active pile would be:

0.09 kg per hour

or 90 x $10^9$ nanograms per hour

or 90 x $10^{12}$ nanograms per hour*

## Emissions from the Crushing of Rejected Pipe

The waste consisting of rejected pipes and scraps amounts of 13.2 metric tons/day at this plant. Visible emissions can be observed during the crushing operation at the dump, indicating that this operation may be a significant source of emissions. It was assumed that 0.01% of the rejected material becomes airborne, of 32.5 kg/month (1.3 kg/day of operation). The pipe is crushed for one day a month. The emission rate is averaged over the entire year with 25% by weight of this emitted material considered to be asbestos, yielding the following:

0.009 kg per hour

or 9 x $10^9$ nanograms per hour

or 9 x $10^{12}$ asbestos fibers per hour*

## Emissions from the Inactive Pile

The emissions from the inactive pile are a function of the size of the pile and the rate of emissions coming off the pile. It has been assumed that the emission rate from an asbestos pile asymptotically approaches 1/5 the emission rate of the active pile, thus, the emission rate is assumed to rapidly approach 22.2 kg/hr/$km^2$ and remains constant at 22.2 kg/hr/$km^2$ once an asbestos pile becomes inactive.

The older the asbestos facility is, the larger the inactive pile becomes and the greater the emissions from this source. In the model plant, the inactive pile contains five years of waste material. However, in another five years, the emissions from the inactive pile will double. Thus, the inactive pile must be prevented from becoming the primary emission source.

If the emissions from the inactive pile are uncontrolled, the annual emission rate increase, proportional to the increase in pile area, will be:

0.018 kg per hour

or 18 x $10^9$ nanograms per hour

or 18 x $10^{12}$ asbestos fibers per hour*

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* A conversion factor of 1,000 fibers per 1 ng was used; this is in agreement with the literature and also with the results obtained from electron microscope data obtained during this study, see page 80.

## Total Emissions from Asbestos Disposal Operation

The total emissions from the dump is the sum of the emissions from the four primary sources. The total emissions for an uncontrolled dump at several ages is shown in Table 4. The emissions from the inactive pile can be seen to depend upon the number of years of accumulated waste. A three fold increase in emissions occurs as the waste accumulates over a period of twenty years. Thus, although the annual increment in the emission rate from the inactive pile might be considered negligible, the long term effects are cumulative and can become the dominant source of emissions.

TABLE 4. EMISSION RATES OF UNCONTROLLED INACTIVE PILE AT SEVERAL AGES

| | Emission Rates, kg/hr | | |
|---|---|---|---|
| Emission Sources | 1 yr | 10 yrs | 20 yrs |
| Active Dump Site | 0.090 | 0.090 | 0.090 |
| Crushing of Reject Pipe | 0.009 | 0.009 | 0.009 |
| Dumping of Fines | 0.034 | 0.034 | 0.034 |
| Inactive Pile | 0.018 | 0.180 | 0.360 |
| TOTAL EMISSION RATE | 0.151 | 0.313 | 0.493 |

## Annual Average Ground Level Airborne Asbestos Concentration

If one assumes the asbestos that becomes airborne will remain suspended, then the dispersion techniques utilized for gaseous pollutants can be applied to asbestos. Using Turner's Workbook for Atmospheric Dispersion Estimate,[22] the area affected by various asbestos fiber concentrations was calculated. The annual average concentrations were based on the following assumptions:

- All asbestos emissions originated from a single ground level point source, with an average wind speed of 2 m/sec.
- An average stability class of "C", as described by Turner, was assumed.
- A prevailing wind direction is assumed. For the purposes of this study, we will assume that the people downwind of the plant will be the only ones affected by the asbestos emissions.